

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 02-1B-028 -X**

**SUBSYSTEM NAME: LANDING/DECELERATION - BRAKE/SKID CONTROL SYS
REVISION: 4 12/20/96**

PART DATA

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: MLG BRAKE SYSTEM	MC621-0055
SRU	: BRAKE/SKID SERVO VALVE	MC621-0055-0012

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
CARBON BRAKE/SKID CONTROL SERVO VALVE**

**QUANTITY OF LIKE ITEMS: 8
LEFT HAND-FOUR RIGHT HAND-FOUR**

**FUNCTION:
METERS HYDRAULIC PRESSURE TO BRAKE CHAMBER (THROUGH MODULE BRAKE
PORT) IN PROPORTION TO ELECTRICAL COMMAND RECEIVED FROM THE BRAKE/SKID
CONTROL BOX.**

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REVISION#: 3 12/20/96

SUBSYSTEM NAME: LANDING/DECELERATION - BRAKE/SKID CONTROL SYS

LRU: MLG BRAKE SYSTEM

CRITICALITY OF THIS

ITEM NAME: CARBON BRAKE/SKID CONTROL SERVO VALVE

FAILURE MODE: 1/1

**FAILURE MODE:
JAMMED OPEN**

MISSION PHASE: DO DE-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:	102	COLUMBIA
	103	DISCOVERY
	104	ATLANTIS
	105	ENDEAVOUR

CAUSE:

CONTAMINATION, FLAPPER ASSEMBLY BROKEN, SECOND SLIDE STAGE JAMMED, FILTER PLUGGED.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

- A) N/A
- B) N/A
- C) N/A

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

LOSS OF BRAKE APPLICATION CONTROL ON 1/2 OF ONE BRAKE BY CREW.

(B) INTERFACING SUBSYSTEM(S):

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UNCONTROLLED APPLICATION OF HYDRAULIC POWER THROUGH AFFECTED SYSTEM TO BRAKES.

(C) MISSION:

POSSIBLE LOSS OF MISSION/CREW/VEHICLE DUE TO BRAKE PRESSURE APPLIED BEFORE DEROTATION RESULTING IN BRAKE/WHEEL/TIRE FAILURE AND UNCONTROLLABLE YAWING FORCES. FOR CARBON BRAKE POSSIBLE LOSS OF MISSION/CREW/VEHICLE DUE TO BRAKE PRESSURE APPLIED (ON TWO OR MORE BRAKE CHANNELS) AT TOUCHDOWN AND AT HIGH SPEEDS THROUGH ROLLOUT CAUSING A SKID CONDITION (LOCKED WHEELS), WHICH RESULTS IN BRAKE WHEEL/TIRE FAILURE AND UNCONTROLLABLE YAWING FORCES POSSIBLY CAUSING FAILURE OF STRUCTURAL MEMBER. DURING ROLLOUT THIS FAILURE IS LESS CRITICAL DUE TO THE ABILITY TO STEER USING NWS AND/OR DIFFERENTIAL BRAKING AND THE POSSIBILITY OF STRUCTURAL FAILURE IS REDUCED.

(D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS (C)

(E) FUNCTIONAL CRITICALITY EFFECTS:

-DISPOSITION RATIONALE-

(A) DESIGN:

THE SERVO VALVE IS DESIGNED TO OPERATE AFTER BEING SUBJECTED TO A SAWTOOTH SHOCK PULSE OF 50 G PEAK MAGNITUDE FOR A DURATION OF 10 TO 12 MILLISECONDS. HYDRAULIC SYSTEM FILTER MODULE IS 5 MICRON ABSOLUTE. THE BRAKE/SKID CONTROL HYD. MODULE INLET AND OUTLET FILTERS ARE 5 MICRON NOMINAL, 15 MICRON ABSOLUTE AND THE SERVO VALVE FILTER IS 15 MICRON NOMINAL, 40 MICRON ABSOLUTE.

(B) TEST:

QUALIFICATION TEST: QUAL TESTING INCLUDES IMPULSE PRESSURE TESTING PEAK PRESSURE 4,500 POUNDS PER SQUARE INCH (PSI), TOTAL CYCLES - 60,000, TEMPERATURE 200 DEG F FLUID -275 DEG F AMBIENT. BURST PRESSURE TEST AT 7,500 PSIG - FLUID AND AMBIENT TEMPERATURE AT 275 DEG F.

ENVIRONMENTAL TESTING INCLUDES; HUMIDITY, SALT FOG, VIBRATION ACCELERATION & SHOCK - TEST SPECIMEN ARE SUBJECTED TO FUNCTIONAL TESTS BEFORE AND AFTER EACH ENVIRONMENT TEST. EQUIPMENT NORMALLY OPERATING DURING EXPOSURE TO THESE ENVIRONMENTS ARE ALSO FUNCTIONALLY MONITORED DURING QUALIFICATION TESTING. THE BRAKE/SKID CONTROL SYSTEM IS SUBJECTED TO 10G UPWARD/7.5G DOWNWARD LANDING ACCELERATION IN THE VERTICAL AXIS AND 0.8

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AFT/2G FORWARD IN THE LONGITUDINAL AXIS. THIS LANDING ACCELERATION IS MAINTAINED FOR A MINIMUM OF 5 MINUTES. HIGH TEMPERATURE TESTING IS PERFORMED PER METHOD 501, PROCEDURE I, OF MIL- STD-810, TEST TEMP IS 275 DEGREES F. LOW TEMP TESTING IS CONDUCTED AT MINUS 80 DEGREES F (NON-OPERATING) AND MINUS 65 DEGREES F (OPERATING).

ACCEPTANCE TEST: ACCEPTANCE TESTS ARE PERFORMED ON ALL UNITS DELIVERED FOR FUNCTIONAL USE - THE TESTS INCLUDE; COMPONENT FUNCTIONAL TESTS & PROOF PRESSURE TESTING. ALL HYDRAULIC COMPONENTS ARE CAPABLE OF WITHSTANDING 60,000 PRESSURE IMPULSE CYCLES WHILE AT FLUID TEMPERATURE OF 200 DEG. F.

OMRSD: BRAKE PEDAL/HYDRAULIC DYNAMIC INSTABILITY;
TEST CONDITIONS -

- (1) RMG/LMG WOW SIGNALS ACTIVATED (INDICATORS OFF)
- (2) HYDRAULIC SYSTEM 1, 2, & 3 SUPPLY PRESSURE: 3000 PLUS OR MINUS 200 LBS.
- (3) SKID CONTROL ACTIVATED (FAIL INDICATOR OFF) DURING THIS TEST EACH BRAKE PEDAL IS DEPRESSED AND HELD AT A POSITION TO ACHIEVE AN APPROXIMATELY 1.7 VDC TRANSDUCER OUTPUT AND CORRESPONDING BRAKE PRESSURES FOR BOTH INBOARD AND OUTBOARD BRAKES ARE VERIFIED.

HYDRAULIC SWITCHING/CONTROL VALVE:
THIS TEST VERIFIES OPERATION OF THE BRAKE MODULE AS DIRECTED BY THE ANTI-SKID CONTROL BOXES "A" AND "B".

FREQUENCY - ALL VEHICLES AT GROUND TURNAROUND.

(C) INSPECTION:

RECEIVING INSPECTION

MATERIAL AND PROCESS CERTIFICATIONS ARE VERIFIED BY INSPECTION. RECEIVING INSPECTION VERIFIES FUNCTIONAL CHARACTERISTICS.

CONTAMINATION CONTROL

INSPECTION VERIFIES CLEANLINESS AND CORROSION CONTROL REQUIREMENTS.

ASSEMBLY/INSTALLATION

VALVE VISUALLY AND DIMENSIONALLY VERIFIED DURING FABRICATION. DESIGNATED SHUTTLE PROJECT FABRICATION AREA VERIFIED BY INSPECTION ACCEPTABLE PRIOR TO FABRICATION.

CRITICAL PROCESSES

INSPECTION VERIFIES EDM AND GRINDING. INSPECTION VERIFIES MAGNETIC PARTICLE INSPECTION AFTER GRINDING TO CATCH ANY POTENTIAL CRACKS FROM THE GRINDING OPERATION.

NONDESTRUCTIVE EVALUATION

INSPECTION VERIFIES X-RAY, PENETRANT AND MAGNETIC PARTICLE INSPECTION OF VARIOUS PARTS.

TESTING

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ACCEPTANCE TESTING INCLUDING PROOF PRESSURE FOR EXTERNAL LEAKS IS VERIFIED BY INSPECTION.

PACKAGING/HANDLING
HANDLING AND PACKAGING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

CAR NO. A3882 - DURING ATP, PRIOR TO QUAL, UNIT EXPERIENCED EXCESSIVE HYSTERISIS ON J2 CONTROL VALVE THAT WAS INDICATIVE OF CONTAMINATION OR A PLUGGED ELEMENT. IT WAS DETERMINED THAT OPERATION AT MINUS 65 DEGREES F. CAUSED THE BRAKE PORT FILTERS TO RUPTURE INTRODUCING CONTAMINATION INTO THE UNIT.

CORRECTIVE ACTION: REQUIREMENT OF MINUS 65 DEGREES F. OPERATING CHANGED TO MINUS 65 DEGREES F. NON-OPERATING, CAPABLE OF OPERATING AT MINUS 10 DEGREES F AND OPERATING TO FULL PERFORMANCE AT PLUS 30 DEGREES F. THUS MEETING THE SHUTTLE HYDRAULIC SYSTEM OPERATING REQUIREMENTS. CAR KB0014-010 - DURING VEHICLE CHECKOUT OF THE ORBITER BRAKE SYSTEMS ONE CHANNEL ON THE HYDRAULIC BRAKE MODULE (S/N 116) EXHIBITED A LAGGING RESPONSE TO PEDAL COMMANDS AND HELD PRESSURES OF 340 TO 990 PSIA AFTER PEDAL RELEASE. THE CAUSE WAS ATTRIBUTED TO SILTING WHICH IS COMMON TO HYDRAULIC UNITS AFTER LONG PERIODS OF INOPERATION. CORRECTIVE ACTION: PROCEDURES ARE INCORPORATED IN BOTH GROUND AND CREW OPERATIONS TO PREVENT AND CLEAR FAILURES.

(E) OPERATIONAL USE:

AFTER ONBOARD ANNUNCIATION (FDA: BRAKE PRESSURE GREATER THAN 180 PSI) TIME PERMITTING, CREW WILL CLOSE HYDRAULIC SYSTEM ISOLATION VALVE(S) (SYSTEMS 1 & 3 OR SYSTEMS 2 & 3). THIS ACTION ISOLATES THE HYDRAULIC SYSTEM(S) FROM THE BRAKES. AFTER NOSE GEAR TOUCHDOWN, SOFTWARE COMMANDS HYDRAULIC ISOLATION VALVE #3 OPEN THEREBY RECOVERING FULL BRAKING FOR ROLLOUT.

IF UNCOMMANDED PRESSURES ARE DETECTED DURING A MISSION THE CREW WILL PERFORM THE FOLLOWING:

- A. SHUT OFF THE ISOLATION VALVE TO AFFECTED BRAKE. IF PRESSURE DOES NOT CLEAR THEN,
- B. RE-OPEN VALVE, THEN SHUT OFF APU TO THE AFFECTED BRAKE

- APPROVALS -

EDITORIALLY APPROVED : RI
 EDITORIALLY APPROVED : JSC
 TECHNICAL APPROVAL : VIA JSC

Robert Stoll Jr
Adam Stacey
 :96-CIL-011